THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

JUNE, 1888.

Thou Lord in the beginning hast laid the foundation of the earth and the heauens are the works of thy hands.

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DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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THE SURFACE OF THE SUN.

THE EDITOR.

In the March number of this journal we stated the problem of the sun's distance and mentioned some of the difficulties met in trying to find its value in any known terrestrial unit of measure. We briefly noticed methods of work, and gave, probably, the best approximate results derived from all work down to the present time. Unofficial information concerning work on the last transit of Venus, now nearly finished, does not materially change the conclusion previously stated. In this connection we desire also to refer the reader to a most excellent article by Professor A. Hall of Washington, enlitled *The Constant of Aberration*, and published in the *Astronomical Journal* (Nos. 169 and 170), more especially for the sake of the following paragraph which suggests a method of finding the distance of the sun not before noticed, and which, in Professor Hall's opinion, is the best that astronomers now have:

The constant of aberration has an interesting connection with the solar parallax. If we designate by k the number of seconds which light requires to pass over the mean distance of the earth from the sun, by φ the angle whose sine is the eccentricity of the earth's orbit, by M the mean anomaly of the earth, and by t the time, we have by definition

$$\frac{k}{\cos \varphi} \cdot \frac{dM}{dt} = \text{constant of aberration} = c.$$

If v be the velocity of light, a the mean distance of the earth from the sun, R the equatorial radius of the earth, and π the solar parallax then

$$v = \frac{a}{k}; \qquad a = \frac{R}{\pi};$$

and eliminating k we have

$$\pi'' = \frac{R}{cv \cos \varphi} \cdot \frac{dM}{dt} \times 206265$$

We have from observation

$\log \frac{dM}{dt} = 8.613493$ Hansen

$\log \cos \varphi = 9.999939$ "

$R = 3963.3$ miles Clarke

$v = 186325$ " Michelson and Newcomb

$c = 20''.4542 \pm 0''.0144$ (derived above).

These numbers give for the solar parallax

$$\pi = 8''.810 \pm 0''.0062$$

There are two theoretical corrections to be applied to the constant of aberration. In the first place the motion of a planet is around the center of gravity of the planet and sun, and not around the center of the sun. This correction is

$$\frac{20''.45 \times m}{a}$$

m being the mass of the planet, and a its mean distance from the sun (BESSEL, *Fund. Astr.*, p. 132). Since for the earth

$$m = \frac{1}{326800}$$

this correction is 0".00006, and can be neglected.

A second correction is required on account of the motion of the solar system in space (BESSEL, *Tabb. Reg.*, p. XIX). As yet we have only rough determinations of this motion, since at present accurate observations of the stars do not extend over a sufficient interval of time. STRUVE's estimate of this motion is 1.6 per annum, the mean distance of the earth from the sun being the unit. This motion would give for the correction to the constant of aberration 0".0005, as a maximum which could change the position of a star. It is therefore probably too small ever to be recognized by observation. The theory of these corrections has been elaborately discussed by M. VILLARCEAU in the *Conn. des Temps* for 1878, where he has treated also the motion of our sidereal system.

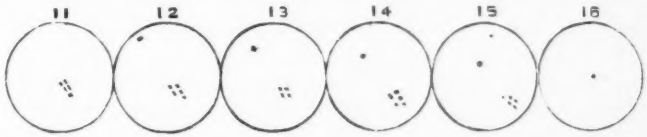
Considering the smallness of these corrections, and the accuracy with which the velocity of light is known, I think the above method of determining the solar parallax is the best that astronomers now have.

After the solar parallax, we called attention to the opinions of some prominent astronomers in relation to the constitution of the sun, with some of the objections that have prevented a general acceptance of those opinions. We now invite attention to a study of the surface of the sun as it appears in the telescope, as it is now understood by the aid of the spectroscope, and by the assistance of of the photographic lens.

The appearance of the sun to the naked eye, properly shielded from its intense light, is that of a flat circular disc, uniformly bright, if not clouded at the time by very large sun

spots. In the telescope with only moderate power, the solar surface commonly shows small spots, faculæ and a granular structure whose general appearance is well known to all observers, but the full and satisfactory explanation of which none claim even now certainly to know.

The discovery of sun-spots was made in 1610 by Fabricius and Galileo, and at this time began progressive study of the surface and the constitution of the sun. By careful observation of the sun-spots it was first and soon learned that the sun has a rotary motion round a fixed axis. To show how the spots would appear to move on the solar surface, the following drawing is given which is taken from the observing book of one of the subscribers to the MESSENGER and belongs to six days of the month of November, 1884.



From information like this Galileo claimed that the time of the sun's rotation was about twenty-eight days, and that the solar axis was inclined to the ecliptic by a small angle. We know that the mean time of the sun's rotation is twenty seven days and nine hours, and his inclination 7° 15′. But the most important queries that were asked by all early observers were concerning the nature of the sun-spots. The difficulties attending detailed observation then to secure enough data for any hypothesis gave rise to a number of different theories to account for the cause and meaning of those spots "in the eye of the world." Jean Tarde thought them transits of planets across the solar disc. Simon Marius believed in the *slag* theory. Derham accounted for them by volcanic eruptions; while Lalande and Cassini said the spots were rocky elevations uncovered by the casual ebbing of the luminous ocean we call the solar surface. So from the time of the invention of the telescope for 164 years, progress in knowledge pertaining to the sun was limited to an approximate period of his rotation, inclination to the ecliptic, and spot zones north and south of his equator.

In 1769 Alexander Wilson said that spots were openings in

the bright surface of the sun through which the dark and real globe could be seen. His proof was the foreshortening of the penumbra as the spot approached the limb, and the notch made when exactly on the limb. Herschel carried the last theory further, making the central globe cool, solid and habitable and the shell of luminous cloud; without the source of light and heat for the solar system. The theory was ingenious and won a host of friends among the scholars until the spectroscope made belief in its splendid imagery no longer possible.

Next in order come the views of Secchi, Faye, Young and Langley. In Secchi's view the spot is formed of a central region—apparently a dark mass—called the nucleus or umbra, or both, surrounded by a part less dark, the penumbra, which is a thin veiling of filaments or currents precipitating themselves towards the center and sometimes crossing it like a bridge. The existence of the spot has three periods, its formation, its rest and its extinction. In the first, the visible solar surface, or photosphere is distorted by great agitation. Its irregular movements defy description, and their velocities are enormous. They have no parallel at all in terrestrial phenomena. This solar activity is produced by tremendous forces at work beneath the photosphere, and the spots, and eruption of great whirling masses of incandescent metallic vapors, are the effects. In the period of rest these eruptive masses fall back again into the surface of the photosphere and form a more or less circular umbra or spot, and the central up-rush loses in volume and velocity. Finally the eruptive action is exhausted and the absorbing powers of the vapors seem to be dissipated, the photosphere closes over the umbra and the spot is extinguished. At first the spot was a rent in the photosphere, then later it assumed the funnel shape in more definite outline, and was crowned with beautiful faculæ and jets of hydrogen and metallic vapors, the former being often abundant, high and bright, while the latter are low and brilliant. This briefly is Secchi's explanation.

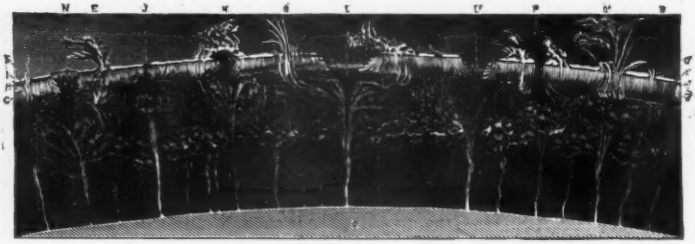
M. Faye's study of solar spots agrees in the main with the foregoing, and emphasizes in addition some particulars worthy of notice. He agrees with Carrington that there exists a simple relation between the latitude of the

spots and their angular velocity, but that the parallax of depth, estimated at $\frac{1}{200}$ of the radius of the sun, must be considered, and also, certain oscillations of small extent and long period in order to obtain the exact relation sought. He holds that contiguous bands of the photosphere are rotating with different velocities as the results of gyratory motions about vertical axis extending to great depth; that velocities in the direction of rotation independent of mean angular motion are less towards the poles of the sun; that the nucleus is depressed in respect to the photosphere; that the whirlpools of the sun, like those of the earth, vary in size from the pore to the great spot, and that the penumbra of a spot is due to that portion of the photosphere which forms around their conical surface at a lower level on account of the lessening of temperature produced by the whirlpool. M. Faye has most trouble in explaining the periodicity of the spots.

Professor Young adopts M. Faye's views for the most part, but adds significant details of theory with characteristic insight and scholarly grasp. He believes that the solar globe, except possibly a thin outer shell, is in a gaseous condition with temperature so high, and under pressure so great that chemical interaction is impossible, that the gases are viscous and behave more like tar or honey than air; that from the under surface of the photosphere there is an immense precipitation of "solar rain" descending into the gaseous core; that from the constricting pressure of the cloud shell and descending products of condensation, the internal gases are forced upwards through the intervals between the clouds with great velocity; that the lower portions of the chromosphere are rich in all the gases and vapors which enter into the sun's composition; that Faye's theory he can not reconcile with the want of systematic rotation of the sun's spots, or their peculiar forms, and that the accelerated motion of the sun's equator is the most important of the unexplained facts in solar physics which probably, when understood, will furnish the solution of most other perplexing questions pertaining to the constituttion of the sun that still face the astronomer of to-day for answer.

The best way now at hand to bring the substance of the forgoing views to the eye is by means of an illustration of

the interior structure of the solar envelope given by E. L. Trouvelot of France not long ago, in a complete and instructive article on this theme, which the author had the kindness to place on our table. The following cut is a reduced copy of a fine lithograph plate accompanying the article referred to:



SUPPOSED INTERIOR STRUCTURE OF THE SOLAR ENVELOPE.

The paper was written in French, and it has been translated in part that Professor Trouvelot's own description might be given to our readers as another statement of conditions, the substance of which may have been read in American authors, but the details of illustration have not been before so fully attempted.

"The envelope which limits the brilliant surface of the sun, named the photosphere, H, H′, forms a sort of immense spherical shell of which the thickness is relatively small. This envelope in which are produced openings which are known to us under the name of solar spots, is composed of an innumerable quantity of vertical filaments due to the condensation of metallic vapors projected from the interior and held in suspension at nearly the same height as the centre of the vapors of comparatively little luminosity, which separate the filaments and hold them at a distance, G, G′. Each of these elementary filaments of which this envelope is formed contains in itself all the substances which compose it. It is the same as the vapors that separate them, which are formed of the same substance as the filaments which form these in their condensation. In reasoning of the filamentary structure of this spherical envelope of the sun, it would be well to distinguish it from the photosphere by giving it the name "némátosphere," a name much more appro-

priate than that of the photosphere which pertains only to the surface of those granulations which compose this envelope, and over which light is germinated.

"In the interior of this filamentary envelope, and at a certain depth, is a nucleus whose nature is undetermined, and which may be either solid, liquid, or gaseous, D. But whatever may be the nature of this nucleus, it is certain that it is the subject of violent crises, which are, we may say, permanent, and which extend over the entire surface as is indicated by the faint gray spots which we see everywhere upon the sun, by the minute spots accompanied by faculæ as well as by the hydrogenic protuberances which we perceive all over these latitudes; only these crises are much more violent than anywhere else over the region comprised within 35° each side of the equator.

"The crises of the solar nucleus are manifested by formidable eruptions of hydrogen gas, by metallic vapors, and by incandescent dust which, projected to a considerable height, are seen to accumulate in clouds of fire in the lower part of the nématosphere. The hydrogen mingled with helium, being more light and mobile than the metallic vapors, forms the summit of the eruptive column, and, entering between the filaments which it disperses, and of which it transforms a part into vapors which it carries with it, making a passage for itself, rises above the photosphere partly as an invisible gas which reaches a considerable height, and partly under the form of hydrogenic protuberances, E′, with some traces of metallic vapors at their base; or else, if the explosive force is not so great, it expands simply over the surface, where it forms and maintains the chromosphere F, F′. Whenever these eruptive jets are less nourished and of lower temperature, as sometimes happens at the time of minimum spots, the protuberances which result sometimes subside at the beginning of condensation and take then the filamentary structure peculiar to the nématosphere.

"The vapors, more dense and of considerably more emissive power then hydrogen raise the temperature of the elementary filaments which are rapidly decomposed and reunited in one or more compact masses which lifted to greater or less heights above the photosphere, appear under the form of groups of brilliant faculæ, K, and the metallic protuber-

ances pertain to the eruptive type, G, G′, which reproduce to our eyes the form and extent of those eruptive columns lying under that which gave them birth. Thus we see that the general form of these facular groups is always more or less circular, as that of the eruptive columns of terrestrial volcanoes obeying the action of their vents. The phenomena which we have just described are peculiar to the zone of spots, but in the higher latitudes of the sun, the eruptions of the nucleus are much less violent nor do they ever attain such grand heights. There is no hydrogen or helium which appears even in the filiform envelope and projecting between the filaments, rise above it in hydrogenic protuberances. In these regions the metallic eruptions only rarely reach even to the surface where they form only small and rare faculæ and very few protuberances of the eruptive type.

"In looking at the effect which the violent eruptions of the spot-regions produce upon the material which composes the filiform envelope, which rise and are transformed into brilliant faculæ and invisible gases, it is possible to think that the temperature of these vapors is so high that all the chemical elements of which they are composed are in a state of dissolution (or dissociation). Reaching the upper part of the nématosphere the metallic vapors, endued with considerable emissive power and exposed as they are to the radiation of space, cool with great rapidity, and their temperature, as Wilson thinks, lowers very soon to the point of condensation. At this moment it produces a phenomenon almost analagous to that described by our eminent compatriot M. Faye, only in place of forming small clouds as the savant thinks, the metallic vapors take the filamentary structure which we have known upon the sun, and they condense at the same time into liquids and incandescent dust, while their elements, thus far dissociated, combine among themselves according to the laws of affinity. This condensation of the metallic vapors upon the one side and chemical combinations upon the other, germinate, where the phenomena are produced, that is, at the summit of each of the filaments, that enormous heat and intense light which the sun constantly radiates into space. This innumerable multitude of centres of condensation and chemical combinations, which have the summit of a filament for a theatre, form together a brilliant

coating exceedingly thin and, we may say, superficial, which alone merit truly the name of *photosphere*, for it is upon this that is born that intense light which the sun radiates H, H′. As these liquids and solid particles, condensing and throwing off an enormous quantity of heat, are much too heavy for the centre where they find themselves placed, they fall in rain toward the nucleus, where the heat causes them speedily to return to the vapor state, and at the same time are replaced in each of the filaments by the condensation of new vapors formed without cessation by the eruptions of the nucleus, condensed without cessation by the cold of space. Thus the filaments of nématosphere interchange and, in consequence, the light of the sun.

"Or, since it is certain after our observations, that the metallic vapors condense in filaments at the surface of the sun, it is true that their condensation is made in the manner noted above, each granulation which in the sum total, is nothing more than the summit of a filament, finds itself encompassed and isolated from its neighbors by a small gaseous envelope composed of the same substances as those which form the filaments, of which, condensed in their turn, they are destined soon to form a part. As these small vaporous envelopes which encompass the granulations owe their orgin to the heat disengaged in the act of the condensation of the metallic vapors into filaments, as well as to that which arises from the chemical combinations which result, their temperature will necessarily be lower, and their light less intense, than that of the granulations; so that they will appear to us as more or less dark and will form around these last a sort of indefinite network resembling that which we see on the solar surface. Further, as these vaporous envelopes which enclose these granulations are at a temperature lower than the last and that, for the rest, they are composed precisely of the same elements, they will absorb the luminous rays emitted by the granulations and will give in consequence an appearance of obscure rays exactly resembling that which we see upon the sun. As the vaporous envelope of the granulation extends not only around but also above them, if we consider them altogether, they will form a thin film continually absorbing which, seen upon the solar edge extends a little beyond the photosphere and during total

eclipses of the sun, reverse the rays of Fraunhofer, where the sun is seen to disappear and again to reappear, I, I.′

"The eruptive columns of hydrogen gas and of helium, when they have small force and volume, enter easily among the elementary filaments of the envelope, which they disperse more or less, and form those pale and light gray and diffuse spots everywhere and always visible on the surface of the sun, B. When these have more force and volume, these gaseous, eruptive columns are introduced in one point only between the elementary filaments which they disperse easily and drive from one part to another, forming soon a small black spot without a penumbra, without faculæ, without interior shadows (or clouds or veils), J. With the gas always flowing the spot continues to enlarge, and little by little it is surrounded by a penumbra due to the light removal of the lower part of the filaments forming the border.

"The incandescent metallic vapors which constitute the less elevated part of these same eruptive columns, endued as they are, with considerable more emissive power than hydrogen, heat rapidly the elementary filaments when they approach them, as often happens over the spot zones, decompose them, and return them to the gaseous state, and mingling with them form these brilliant masses which, lifted above the nématosphere, appear to us under the form of brilliant faculæ, K These openings made in the nématosphere by the decomposition and transformation of the filaments into faculæ, and lifting them above the surface, constitute the solar spots, L, L′, of which the penumbra is formed by the lifting of the lower extremity of the filaments, which form and border the edge of these openings, A, A′.

The solar spots disappear in various ways. In the first class they retire (or disappear) gradually, the neighboring filaments, loosening, encroach gradually over the opening in proportion as the gaseous eruption diminishes and finally end by a heaping together. In the second class the phenomenon is much more complex, they disappear sometimes by an afflux of extensive faculæ which advance and cover the opening, sometimes they are luminous points which sink over them and in retaking the filamentary form, enlarge rapidly finish by the heaping together; sometimes at the last they disappear by condensation over the opening of invisible

vapors in shadowy vapors which become flocculent, then finally filamentary and transform them little by little into veiled spots, N, which are soon effaced entirely by the accumulation of the filaments. Ordinarily the causes which we have mentioned do not act singly to disperse the spots but all at once.

"The faculæ are almost always formed above the invisible openings of the nèmatosphere, and if they were not held in that state by the interior heat which reaches them constantly through the openings which they cover, they would condense very quickly into filaments as often happens. But nevertheless they frequently disappear little by little, being transformed into invisible vapor and leaving in their places the spots which they cover. The last case is scarcely an exception to the rule, for the greater part of the time, the openings of the nèmatosphere remain more or less obstructed by the faculæ and often pass away unobserved, K, or else they are only indicated by the small lateral spots which are seen at the base of the faculæ whenever they are near the solar edge but which disappear when these are at a little distance.

"At present, observation is dumb upon the causes of the eruption of the solar nucleus, and we have learned nothing either of their periodicity nor of that of the spots, the faculæ, and the protuberances which result. As their periodicity may be real or only apparent, we may conjecture that during the minimum periods, the eruptions are more rare and less violent and are principally hydrogenic; while during the maximum periods they are more frequent and more energetic hydrogenic and metallic at the same time. There would result the predominance of the solar spots, faculæ protuberances and metallic spectacles during the latter periods and their rarity during the former.

"If, as we have supposed, it is true that the heat and solar light are due to the interior activity of the sun which produces these eruptions of metallic vapors, and which condense and germinate this heat and light, we may think that, unless the sun gathers and assimilates constantly the material of space, the day will arrive, however distant we may imagine it, when this interior activity diminishing the photosphere will not extend over the entire surface as it

does to-day, but only over a point of the surface, and finally, after alternate action and repose will cease entirely."

This detailed statement of the study of visible solar phenomena is given to aid students or interested readers in comprehending some of the questions in solar physics that the astronomer is trying at the present time to solve. The aid given by the spectroscope and the photograph lens in this study we have hinted at only incidentally. These and the interesting researches on solar temperature by Professor Langley must be a reserved for another time.

(TO BE CONTINUED.)

A FURTHER NOTE ON STAR DISTRIBUTION.

BY W. H. S. MONCK.

For the MESSENGER.

The numerical error in my former note on star distribution renders a fresh discussion of some of the questions raised in it desirable. The principal of these is the extent of the thinning of the stars, which takes place as we pass outwards from the solar system into space.

The theoretical multiplier for one-tenth of a magnitude is not 1.0965 but 1.148, and in trying the reverse process it is not $\frac{1}{1.0965}$ but $\frac{1}{1.148}$. In summing the series therefore for the total number of stars above a given magnitude the expression is not $10.363a$ but $6.757a$ (where a represents the number of stars confined in the next tenth of a magnitude). From this follows a curious law which holds good to less than one per cent viz.: the number of stars brighter than any given magnitude is equal to the number of stars comprised in the next half-magnitude. The numbers for the next five-tenths of a magnitude will be respectively a, $1.148a$, $1.318a$, $1.514a$ and $1.738a$, giving a total for the five subdivisions of $6.718a$ against $6.757a$ as the total number of brighter stars.

This law enables me to show briefly that the thinning out of the stars does not commence until we reach magnitude 2.5. The total number of stars brighter than 2.0 according to the *Harvard Photometry* is 27, and, according to the *Uranometria Nova*, 25. The number of stars between 2.0 and 2.5, according to the former authority, is 30, and, according to the latter, 28. Instead of a deficiency of fainter stars,

therefore, there is at this stage a slight excess. But at the next step the deficiency becomes apparent. There are 57 stars rated higher than 2.5 in the Harvard Catalogue and 53 in the Oxford one, but the number of stars from 2.5 to 3.0 is only 41 in the former and 21 in the latter. And this deficiency seems to be maintained down to the point where the catalogues can no longer be relied on as complete.

If, however, we inquire whether the deficiency is maintained below this point, the answer is more doubtful. The magnitudes of Argelander agree so well with those of Pickering and Pritchard as to indicate that the scale of 2.512 for each magnitude has been practically adopted by Argelander. I am happy to learn that Professor Pickering is at present engaged in researches wich will clear up this question. Schönfeld pointed out long ago in a letter to *the Observatory* that Argelander's magnitudes were not reliable beyond 9.2 or, at the utmost, 9.3. I shall only use them as far as magnitude 9, assuming provisionally that Argelander's magnitudes down to this point are comparable with those of Pickering and Pritchard. Adopting Leebyer's results (as given in the *Observatory*), I find the following particulars for the Bonn Durschmusterung and Schönfeld's southern extension of it respectively.

	No. of stars Argelander.	No of stars Schonfeld.	Total.
Brighter than 9.5	4,120	1,265	5,385
6.5 to 7.0	3,887	1,276	5,163
7.0 to 7.5	6,054	1,828	7,882
7.5 to 8.0	11,168	3,506	14 674
8.0 to 8.5	22,898	7,601	30,499
8.5 to 9.0	52,852	18,633	71,485

Here it is evident at a glance that while the thinning out of the stars is still in progress down to the 8th magnitude, it is not only arrested but reversed between the 8th and 9th magnitudes, the interval 8.5 to 9.0 containing nearly five times as many stars as the interval 7.5 to 8.0, while the theoretical number is slightly less than 4. There is another feature in the table which I cannot reconcile with the results of Pickering and Pritchard, viz.: that the total number of stars brighter than magnitude 6.5 is almost exactly equal to the number of those lying between 6.5 and 7.0 in accordance with the hypothesis of uniformity. The figures would have been materially different if we had gone on to the next succeeding

stage as we would then have 10,548 stars brighter than 7.0 against 7,882 lying between 7.0 and 7.5. At the final stage the excess is in the opposite direction. We have only 63,603 stars brighter than 8.5 against 71,485 between 8.5 and 9.0 Great reliance cannot be placed on these results pending Professor Pickering's investigation, but I think it may be at all events laid down that the thinning out of the stars has only been shown to exist between the limits of 2.5 and 8.0 magnitudes and that there are some traces of a reversal at both ends of the scale.

The limit, or at least uncertainty, as to the thinning out of the stars renders it more difficult to discover its causes. One cause which I suggested is, that we are situated in the Galaxy, the shape of which, therefore, would rather resemble a segment of a cylinder or a flat round cake than a hollow ring. The stars all around us are, on this theory galactic, but there is a plane in which the Galaxy extends much farther than it extends in a direction perpendicular to this plane. Drawing a number of spheres around us with the sun as centre, the surfaces of the inner spheres would be wholly occupied by the Galaxy; but as the spheres became larger and and larger, the Galaxy would occupy a smaller and smaller portion of the surfaces, and each succeeding surface would, as a consequence, contain fewer and fewer stars compared with its extent. The fact that the Galaxy appears nearly as a great circle on the celestial sphere gives some countenance to this theory. But I think the objections to it preponderate. The thinning out of the stars ought to be greater than it is unless the sun is situated in a particularly poor portion of the Galaxy. It ought not to be confined within the limits 2.5 and 8.0; and I may add that researches on parallax do not seem to show that the stars which lie out of the direction of the Galaxy are among our nearest neighbors as they ought on this theory to be.

But the other theory of loss of light in transmission is not more successful in explaining the limits between which the thinning out has been observed, and there appear to be special objections to supposing that the ether absorbs light. If it exercises a selective absorption all the more distant stars should either present a peculiar color or at all events exhibit peculiar lines in their spectra. On the other hand

that bodies capable of intercepting light, especially meteors, exist in space is at all events highly probable; but it may be doubted whether they are numerous enough to intercept an appreciable quantity of light at the distance with which we are now dealing. The whole question thus stands in need of further investigation.

ON THE DISSIPATION OF COMETS.

BY W. H. S. MONCK, DUBLIN.

FOR THE MESSENGER.

That the visits of comets to the neighborhood of the sun are usually attended with a good deal of waste will not, I think, be doubted, nor will it probably be disputed that Biela's comet, at least, has now been finally dissipated in its character of comet. I venture to suggest that the causes of dissipation chiefly exist in or near the ecliptic (or rather, perhaps, the plane of Jupiter's orbit), and that this is the true reason why many comets of short period have not returned. For this purpose I have arranged the comets of short period which ought to have returned since their first discovery in order of their inclinations, and I find the result is as follows:

1. Lexell's comet of 1770; inclination 1°34′. Orbit repeatedly and carefully computed. Period under 6 years; never returned.

2. Clausen's comet of 1743; inclination 1°53′; period about 5½ years. One very doubtful identification; otherwise it never returned.

3. Comet of 1678; inclination, 2°52′; period, according to Le Verrier, similar to the foregoing. One doubtful identification; otherwise it has never returned.

4. De Vico's comet of 1844; inclination 2°54′; period similar to foregoing. Doubtfully identified with No. 3. Never returned since 1844.

5. Tempel's comet of 1869; inclination 5°24′. This is the first in the table that has certainly returned.

6. Tempel's comet of 1867; inclination when discovered 6°24′, but now increased to over 10°, so that it does not now stand sixth in the list. This comet has also returned.

XUM

7. Burkhardt's comet of 1766; inclination 8°1′; period in close agreement with the foregoing six. Has not returned (unless identical with No. 6).

8. Blainpain's comet of 1819; inclination 9°1′; period similar to foregoing. Has not returned.

9. Faye's comet; inclination 11°22′; period a little longer than foregoing. Has returned.

10. Biela's comet; inclination 12°33′. Returned several times but seems to be now dissipated.

11. Tempel's comet of 1873; inclination 12°46′. Has returned.

12. Encke's comet; inclination 12°54′. Has frequently returned.

13. Winnecke's comet; inclination 14°27′. Has returned.

14. D'Arrest's comet; inclination 15°42′. Has returned.

15. Tempel's comet of 1866. Inclination 17°12′ (retrograde). The previous visits of this comet seem to be sufficiently established by the corresponding meteor shower, though it is doubtful whether the comet itself was previously observed. The comet of A. D. 1366, perhaps most resembles it.

16. Halley's comet; inclination 17°45′ (retrograde). Has returned regularly since the Christian era.

Of comets with indications exceeding 20° and periods of less than 100 years, those of Tuttle, Brorsen, Pons-Brooks, and Olbers have returned, while Pigott's of 1783 and De-Vico's of 1846 have not; but the period of the latter is doubtful.

The earlier observations appear in no case to have been sufficiently accurate to show that the orbit was elliptic, but it is worth noting that no periodical comet with an inclination of less than 10° has been identified with a comet observed before the time of Newton, as Halley's comet has been with certainty, and Tempel's comet of 1866 and Brorsen's comet have been with some degree of probability.

The fact that less than half the comets with inclinations of under 10°, for which elliptic orbits have been computed, have returned while all the elliptic comets with inclination between 10° and 20° have returned (though one seems to have been recently dissipated), is, at all events, remarkable. It points, I think, to dissipation, not perturbation as the cause of non-return.

A NEW FORM OF COMET-SEEKER.

BY GEORGE A. HILL.

FOR THE MESSENGER.

Mr. Brashear of Allegheny City, Pa., has recently made for Professor H. P. Tuttle of the Naval Observatory, from designs of the latter, a new form of comet-seeker which embraces so many salient points that I have been persuaded to write a description of it for the MESSENGER.

A NEW FORM OF COMET-SEEKER.

Mr. Brashear read a paper before the American Association, held in New York, describing the comet-seeker, but as that paper may not come to the attention of all the readers of this magazine, I will describe the plan of the instrument.

Through the kindness of Professor Tuttle I have been, for a

short time, using this instrument in my regular comet hunting, and the more I use it the more convinced I become of its great improvement over other forms of comet-seekers.

The wood-cut gives a fair representation of the telescope and its mountings. It is a reflector of 6½ inches aperture, and 40 inches focal length. The telescope tube has a broad collar around its upper end, on one side of which a hub is cast, and which is bored to fit on the end of the declination axis. Directly opposite to this hub the eye-piece holder is mounted, so that when the telescope is swung through any number of degrees of declination, the only movement given the eye-piece is one of rotation; hence the observer is not obliged to change the position of the eye through the entire sweep in declination.

The telescope tube is mounted on a horizontal axis, which is free to move in declination. Encircling the eye-piece will be seen a hand wheel, about 14 inches in diameter, the spokes of which radiate from the eye-piece mounting. The rim of the wheel is made of wood, and of such a size as to be firmly grasped by the hand. By this means the observer is able to move the instrument in declination.

The horizontal axis just mentioned is mounted in a bearing plate, which can be moved rapidly, or, if a slow motion is desired, a tangent screw attached thereto can be used. This tangent screw is capable of being thrown in and out of gear, at the pleasure of the observer.

Attached to the tangent screw is a ratchet wheel and handle, within easy reach of the observer, and which can be so regulated by stops, arranged for it, that "sweeps" of any desired breadth may be taken, thus relieving the observer of the necessity of watching his field. The arrangement just explained can also be used for making horizontal sweeps, or it can be detatched and those sweeps made without it. Should any object be noticed near the edge of the field in the direction in which the telescope is being moved, the ratchet may be instantly released, and by the use of the milled wheel on the tangent screw, the telescope can be moved in the opposite direction.

Just below the eye-piece will be seen a rotating shelf, on which are kept the eye-pieces, and as they are made to slide into the eye-piece holder, no time is lost in making a change in the power used.

The eye-pieces are of the Airy form, the lowest power giving a field of about a degree and a half.

The heavy disc of metal fastened to an arm, on the left hand side of the telescope, acts as a counterpoise, by which means the instrument will remain fixed in any position the observer may wish to place it.

The telescope tube is fastened to an iron tripod stand, and this in turn is fastened to a small carriage supplied with wheels. By this arrangement the instrument can be drawn to different portions of the yard, or, if the observer has a flat roof from which he observes, it can be drawn to different portions thereof.

Through the kindness of the Superintendent of the United States Naval Observatory the new comet-seeker has been mounted on the roof of that building.

A little house has been built in which the instrument is placed when not in use. Around the west and south sides of the veranda surrounding the small dome a track has been built over which the comet-seeker is drawn, so that all portions of the sky can be viewed.

The ease and comfort with which comet-seeking can be carried on with an instrument made after this new model must be self evident.

In my opinion all observers who use the refractor for comet-seeking would, after using this style of reflector, discard the former at once.

I do not make any claim of the superiority of the reflector over that of the refractor; that I will leave to some one who is more competent to judge than I am. But I do claim that the mounting of this new form of comet-seeker is the nearest approach to perfect ease for the observer, to rapidity of action, and handiness with which all parts of the heavens can be surveyed, of any form of mounting known to me.

The ease with which the observer can sweep on the meridian or near the horizon is the same. In sweeping he has occasion only once in about fifteen minutes to move his chair, and if that be mounted on castors his change of position can be regulated by his feet.

ASTRONOMY IN LATE PERIODICALS.

Monthly Notices for March has among its prominent articles the following: The orbit of the binary star λ Ophiuchi, by Professor S. Glasenapp. This star has been observed for sixty-two years, and the elements of the orbit deduced are:

T = 1787.9	$\lambda = 152°.5$ Eq. 1900
U = 373.5 years	$i = 38°.1$
$n = 0.9638$	$\varepsilon = 0.4424$
$\Omega = 105°.5$ Eq. 1900	$a = 1''.53$

These elements will represent the observations for the period above named.

J. E. Gore has computed the orbit for 70 Ophiuchi, using all the available measures from 1819 to 1887, being about 247 in number. The elements are:

P = 87.84 years	$\Omega = 120°5'$ (1880)
T = 1807.5	$\lambda = 171°45'$
$\varepsilon = 0.4912$	$a = 4''.50$
$\gamma = 58°28'$	$\mu = -4°.098$

In connection with this paper the formulæ are given for the computation of an ephemeris.

W. S. Franks publishes the introduction to a catalogue of the mean colors of 758 stars, and an appendix containing the colors of 26 stars. His earlier catalogue of 3,890 stars was made by the aid of a five-inch refractor, and contained naked-eye stars to declination $-25°$.

A. Marth's ephemeris for physical observations of moon for nine lunations from April 12 to the end of 1888 is an instructive and a very useful paper.

Nature for April 19 and 26 contains portions of an address, delivered by J. Norman Lockyer before the Royal Society, April 12, 1888, entitled "Suggestions on the Classification of the Various Species of Heavenly Bodies." The first point discussed related to the probable origin of the groups, especially the nebulæ. Mr. Lockyer starts with the idea that the orgin of the nebulæ is meteoric; that light and the glow of gases come from collisions of meteors; that Herschel's planetary nebula has no star for its center; that Sir John Herschel's theory of "hollow shells" and Arago's hollow spherical envelopes illuminated by a brilliant central body

do not accord with Rosse's observations, which showed all to be perforated by the aid of his colossal telescope, except (as he believed) those nebulæ of the annular form.

The meteoric hypothesis is briefly this: A swarm is supposed to be the center of activity, and its center of gravity is the focus of attraction for a considerable space surrounding, more or less filled with meteorites. The collisions, few or frequent, that naturally arise in such relations, are the source of greater or less light for the mass. "The collision surface will be practically the only thing visible, and will present to us the exact and hitherto unexplained appearance of a planetary nebula—a body of the same intensity of luminosity at its edge and center—thus putting on an almost phosphorescent appearance." The theory is then applied to the globular nebula showing condensations, until finally a nebulous star is reached; also to the spiral nebula and the cometic nebula.

The second branch of the theme is the classification of the stars, based on observation by the spectroscope in which is presented the results of the labors of Fraunhofer, Rutherford and Secchi, bringing out classifications in relation to temperature which are interesting and novel in some respects. This address contains much useful astronomy.

The Astronomical Journal, No. 171, presents a full and carefully written article by Professor George C. Comstock, entitled "An Examination of Some Errors Possibly Affecting Measures of Distance made with the Prism-Apparatus of M. Loewy;" Elliptic Elements of Comet *a* 1888, by Professor Lewis Boss, as follows:

$$\left.\begin{aligned} T &= 1888, \text{ March } 16.9987 \\ \omega &= 359^\circ 54' 58'',4 \\ \Omega &= 245\ 22\ 46\ .6 \\ i &= 42\ 15\ 23\ .1 \end{aligned}\right\} 1880.0$$

$$\log.\ \varepsilon = 9.997790$$

$$\log.\ q = 9.844329$$

Professor Boss says the above eccentricity corresponds to a period of 1,615 years, and that he suspects that the true period will be decidedly greater than 2,000 years.

The elliptic elements of this comet computed by Rev. George M. Searle of New York are nearly identical with those given above. The near agreement of different comput-

ers is partly explained by the fact that the position of the orbit is remarkably favorable for the manifestation of ellipticity if it should exist.

Observatory for May gives accounts of the meetings of the Royal Astronomical Society, Liverpool Astronomical Society, and the Royal Meteorological Society. The paper by the editors, Messrs. Turner and Common, on the photographic chart of the heavens, though brief, deals with the most important phases of this great work projected by the international conference at Paris. The three following resolutions show the aim and scope of the work:

1. "The progress made in astronomical photography demands that astronomers of the present day should unite in undertaking a description of the heavens by photographic means."

2. "The work should be carried out at selected stations, and with instruments which should be identical in their essential parts."

3. "The principal objects are (*a*) to prepare a good photographic chart of the heavens for the present epoch, and to obtain data which will enable us to determine, with the greatest possible accuracy, the positions and the brightness of all the stars down to a given magnitude (magnitude being understood to be defined in a photographic sense), (*b*) to provide for the means of utilizing, both at the present day and in the future, the results of the data obtained by photographic means."

In connection with this plan of work Dr. Gill's proposition to establish a central bureau with officers and computers at an annual cost of $50,000 for a period of fifty years is criticised in strong terms on the ground of cost, and the limited uses of the extended star catalogue proposed.

Knowledge for May gives large space to astronomical themes. The first is "The Star Story of the Flood." It begins with a description of the ancient skies at the date 3,400 years B. C., and the writer finds, with a star map of that date before his eyes, familiar passages of the ancient poets are explained; and, assuming this as the probable date of the Great Pyramid of Egypt, there are many points in and about it that signify purposes which it served for ancient astronomy and astrology. The first part of the article

closes with a comparison of the ancient and the modern constellations, claiming that the former much more nearly represented the objects bearing their names than the later ones do.

"The Canals and Rivers of Mars" is a discussion of Schiaparelli's views concerning details on the surface of Mars which he has repeatedly observed, and which he calls great parallel canals. As Mars is now nearest to earth for the present year, observers with large telescopes have opportunity to study these markings for themselves. The writer in *Knowledge* holds that the parallel tracings seen are not canals, but probably rivers so modified by atmospheric and other possible conditions as to give them the appearance of the dark streaks plainly mapped by Schiaparelli.

Another paper, entitled "Weighing the Earth," gives the details of working out the result by simple methods. A further method by means of leaden weights, first suggested by Professors Richer and Meyer of Berlin, is proposed as worthy of consideration and trial, for a direct comparison between the weight of a large leaden ball and that of the earth.

Journal of Liverpool Astronomical Society for May continues the illustrated notes of the planets by Mr. Denning, with Mars as the theme. He refers to the markings of that planet's surface, known as the parallel canals of Schiaparelli, and says that the present opposition will afford opportunity for their study by the aid of large telescopes. The apparent diameter of Mars at opposition in 1887 was 29″.2; in 1888, 18″.4. More favorable opposition will occur in 1890 and 1892 than for this year. When it is remembered that Schiaparelli saw, in the clear skies of Milan, these canal markings when the disc of Mars was only 13″ in diameter, the giant telescopes of the present time ought to be able to test his observations with good degree of certainty. His statement of power necessary to do this is that "every telescope able to distinguish a dark line 0″.2 in breadth on a dark background, and to separate the one from the other of two such lines when the interval between axis and axis is 0″.5, could be employed for these observations, and to study the duplications if these should be reproduced. In the Milan instrument, the aperture of which does not exceed eight French inches, the greater number of

the canals and their pairs were observed with comparative ease whenever the air was still, and only a few cases required a special effort on the part of the observer." M. Perrotin of Nice, with a Henry equatorial of fifteen inches, has seen these markings, with powers 450 and 560, and noticed that some of them were double. He estimates that the phenomena may be produced by clouds or mists circulating in the atmosphere of Mars.

Other interesting papers of this number are: "Comet-seeking," by W. Doberck; "Secondary Light of Venus," by W. T. Lynn; "Water on the Moon," by W. Durham; "Evidence of Subsidence of Lunar Maria," by S. E. Pearl; and the study of the walled plain, "Messala," on the moon, by T. G. Elger.

SUPPOSED OBSERVATIONS OF COMET 1887, I.

PROFESSOR LEWIS SWIFT.

For the MESSENGER.

This is the comet which, on Jan. 8, 1887, so suddenly made its apparition in the southern heavens. It was apparently headless, seeming to consist altogether of train. The first announcement of discovery which reached the northern hemisphere, was made by Mr. Thome of the Cordova Observatory, and, for a while it seemed that he was clearly entitled to the Warner comet prize of $100, but his claim is now contested by Mr. W. H. Haley and others of Australia. On the evening of Feb. 13, setting my telescope as indicated by Mr. Chandler's ephemeris, in about the same R. A. and some degrees farther south, I picked up an object, new to me, which, as it had a cometary aspect and was so near the computed place, I was almost sure was the South American comet. It was perfectly round and without tail. After a moment's observation, I detected, about 4′ north, an exceedingly faint, pretty small, round nebula.

Cloudy weather prevented a subsequent observation and a full year elapsed before an opportunity came to re-examine the place. I have been able to make only three attempts at re-observation, and, each time, the seeing was not exquisite enough to reveal the faint one, but, on two or three occa-

sions, sufficiently good, I felt certain to have shown the bright body had it been there.

In consequence of the erection of a large number of electric street lights south of the observatory, and of the low altitude of the objects, I fear I shall be ever unable to re-find the fainter one which would serve as my guide to the place of the other. Under the best conditions of seeing, in any latitude, a telescope of about fifteen inches aperture would be required to see it.

In calling attention to this matter my object is to prevent the readers of THE SIDEREAL MESSENGER from forming an erroneous opinion from the statements regarding it by Dr. H. C. Wilson, on page 157 of that magazine for April. He gives as the sentiment of Professor Barnard's letter in the *Astronomische Nachrichten*, that he (Professor Barnard), though he had sought in vain for my objects, yet he had found in the same declination, but differing fifteen minutes in right ascension, two nebulæ, one about 4′ north of the other, which, in his opinion, might be the two seen by myself. The doctor seems either not to have seen, or to have forgotten, my letter of reply published also in that journal. Mr. Barnard's nebulæ I have for years been familiar with, and I re-examined them last February for comparison. They are not identical with those under debate, nor do they bear any marked resemblance to them.

Owing to the uncertainty of the observations of the comet in the southern hemisphere, probably not great reliance can be placed on any ephemeris, and though, doubtless, Chandler's may have been as nearly accurate as any, yet the difference from the computed position of the comet at that date did not hinder me, under the circumstances, from strongly suspecting it to be that body. The agreement was quite close in right ascension, but the declination differed about three degrees.

It is not at all surprising that Professor Barnard, with a six and one-half inch telescope (not eight inch as Dr. Wilson says), failed to detect the faint nebula so near the bright one. I still strongly suspect that the object I saw was a comet, and though, of course, it may not have been Comet 1887, I, yet I incline to think that it was.

FOR STUDENTS AND YOUNG OBSERVERS.

Interesting Phenomena for June and July.

THE PLANETS.

Mercury will be at greatest elongation east of the sun June 12 at 2 P. M., and will be in favorable position for observation in the early evening during the greater part of the month of June, setting from an hour to an hour and three-quarters later than the sun. He is coming between the earth and sun, and will reach inferior conjunction July 8, being then about five degrees south of the sun. At the same time Venus and the moon will be in the same region of the sky, within five degrees of the sun. The diameter of Mercury's disc on June 12 will be 8.2″, and at the end of the month will have increased to 12″. During the latter part of July Mercury may again be observed in the morning, west of the sun, although its position will not be so favorable as in June. Very little is known with regard to the surface markings of this planet, or its period of rotation, and it is one to which amateurs devote very little attention, chiefly because of the difficulty of obtaining good images. The smallness of the disc, and the fact that it is usually observed near the horizon, where the waves of heated vapor cause a flaring and distortion of the image so that the phases can scarcely be made out, are serious drawbacks to anything like accurate observations. Mr. W. F. Denning, however, in the February number of the *Journal of the Liverpool Astronomical Society*, has called attention to the fact that the observations need not be made at a low altitude, and that, by selecting suitable times, very satisfactory views of this planet may be obtained. He says, "As a naked-eye object Mercury must necessarily be looked for near the horizon, but there is no such need in regard to telescopic observation, which ought to be only attempted when the planet has surmounted the dense lower vapors and attained sufficient elevation to give the instrument a fair chance of producing a steady image. The presence of sunshine need not seriously impair the definition, or make the disc too faint for detail, but care must be taken to shield the telescope from the sun's

rays, or annoying currents will be generated in the interior of the tube, and these will ruin the view. I have occasionally seen Mercury about two or three hours after his rising, with outlines of extreme sharpness and quite comparable with the excellent views of Venus at the time of sunrise and sunset. Those who possess equatorials should pick up the planet in the afternoon and follow him until after sunset, when the heated vapors will interfere. Others who work with ordinary alt-azimuth stands will find it best to examine the planet at his western elongations during the last half of the year, when he may be found soon after rising by the naked eye, or with an opera glass, and followed in the telescope for several hours if necessary."

Venus is in a very unfavorable position for observation, approaching superior conjunction with the sun. The apparent diameter of her disc will be less than that of Mercury during the greater part of the month, and she is so nearly in line with the sun that it will be very difficult to find her with ordinary telescopes. Venus will be at the ascending node of her orbit June 20; in conjunction with Mercury, on the opposite side of the sun, apparently and really, July 8, at 11 P. M., central time; in conjunction with the moon, north 1°57′, at the same time; at superior conjunction with the sun, north 47′ from the sun's center, July 11, at 1 P. M.; in perihelion, July 23; in conjunction with Saturn, July 27, 7 A. M.

Mars will be in good position for observation during June, although he is receding from the earth and his disc is therefore growing smaller, diminishing from 13.2″ June 1 to 10.6″ July 1. Mars may still be seen in the southwest in the early evening during July, but his low altitude will prevent good seeing. Reference is made elsewhere to a paper by Mr. W. F. Denning, in the *Journal of the Liverpool Astronomical Society*, in which he speaks of the most curious features of Mars' surface, the so-called "canals," which were observed by Schiaparelli at Milan in 1881 to run in parallel pairs. This duplication of the canals has been observed since by Mr. Perrotin at Nice. A note, by Mr. R. A. Proctor, on this subject was read at the April meeting of the Royal Astronomical Society. In the discussion which followed the reading of the note Mr. Knobel said: "I quite agree with Mr.

Proctor that there is a great difficulty in accepting the chart of Mars as depicted by Schiaparelli. The parallelism of the canals is so amazing that one cannot but seek for some explanation as was suggested some time back by Mr. Green, those lines being the boundaries of faint tones and shadows on the planet, or, as Mr. Proctor has suggested, there being some light spaces between certain dark marks which Schiaparelli has interpreted into lines like canals. Certainly I have over and over again recently, as well as at every opposition, failed to see anything approaching parallelism in the configuration of the planet. I have not seen the slightest signs of it and it does not appear that, with the exception of the observations made at Nice, any one has seen anything like these parallel canals spoken of by Schiaparelli."

Jupiter is now in its best position for observation this year, crossing the meridian between 10 and 11 P. M. There is no difficulty in recognizing this brilliant planet among the bright stars of Scorpio in the southeast in the early evening. He has been retrograding for some time, but his motion is very slow. July 22 he will become stationary, and after that will advance toward the east. The objects on Jupiter's surface which specially attract observers are the old red spot, the brilliant white spots on the north borders of the great equatorial belts, and the belts and spots closely south of the red spot. It is known that different spots have different periods of rotation, and observers may do useful work in noting the time when different markings come to the central meridian of the planet, and their position north or south of the equator. Mr. Denning has given an interesting discussion of the features of this planet in the March and April numbers of the *Journal of the Liverpool Astronomical Society*.

Saturn will be pretty low in the northwest for good observation, but may be seen in the first hours of the evening during June. During July he will be near the sun, coming to conjunction August 1. Saturn will be occulted by the moon, to observers between the parallels of latitude north 36° and south 24°, July 10, 1 P. M. central time. The occultation will occur in full sunlight, when the planet is only one hour and a quarter east of the sun, but it may possibly be ob-

served by taking proper precautions to shut the sunlight out from the telescope.

Uranus will be in conjunction with Mars June 6 at 11 P. M., north 47′. The two planets will then be in the same field of view of an ordinary finder. One will thus be able to compare directly the greenish hue of the one with the ruddy color of the other. Uranus will be stationary June 19, and in conjunction with the sun July 4.

Neptune comes into view again in the morning, west of the sun. It is in Taurus a few degrees south of the Pleiades.

A Partial Eclipse of the Sun will take place July 8, but will be visible only in the South Indian and Antarctic oceans.

A Total Eclipse of the Moon, July 22, will be visible generally throughout North and South America and portions of Europe, Africa and the Pacific Ocean.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, July 22*d*, 17*h* 44*m* 29.5*s*.

	h m s		s
Sun's right ascension	8 11 48.02	Hourly motion	9.92
Moon's right ascension	20 11 48.02	" "	147.84
Sun's declination	20° 00′ 12.7″ N.	" "	0′ 31.0″ S.
Moon's declination	20° 01′ 44.7″ S.	" "	4′ 24.0″ N.
Sun's equa. hor. parallax	8.7	Sun's true semidiameter	15′ 44.9
Moon's equa. hor. parallax	58 43.0	Moon's true semidiameter	15 59.2

TIMES OF THE PHASES.

	Washington mean time. d h m	Central time. h m
Moon enters penumbra	July 22, 9 47.3	8 55.5
Moon enters shadow	10 46.5	9 04.7
Total Eclipse begins	11 45.4	10 53.6
Middle of the eclipse	12 36.6	11 44.8
Total eclipse ends	13 27.8	12 36.0
Moon leaves shadow	14 26.6	13 34.8
Moon leaves penumbra	15 25.7	14 33.9

Magnitude of the eclipse = 1.825 (moon's diameter = 1).

Probable Occultation of Stars by the Principal Planets. In L'Astronomie for May Mr. B. Lihou gives a list of probable occultations of stars by the planets Venus, Jupiter and Saturn during the year 1888. Such occultations have been very rarely observed because they have never been predicted. They would be of use in the study of the physical constitution of the planets, and especially would an observation of an occultation of a star by the rings of

Saturn throw light upon the nature of those strange appendages. It happens, however, that only one of the probable occultations noted by Mr. Lihou will be visible in the United States, viz., that of a 7.7 magnitude star by Jupiter, August 7, 9:22 P. M. central time; maximum duration 358 minutes.

THE CONSTELLATIONS.

At 9 P. M. in the middle of June, Cancer, with the cluster Præsepe and the planet Saturn, is setting in the west. Leo, with the bright star Regulus and the well-known group of the Sickle, is a little less than half way up from the west horizon to the zenith. The second star from Regulus in the Sickle, γ Leonis, is a fine double. The components are about 4″ apart, and their magnitudes, 2d and 4th. It is a binary, having a period of about 400 years. Above Leo is the constellation of Berenice's Hair, an area dotted with faint stars just visible to the naked eye. Not far south and a little west of the zenith one will recognize Arcturus, the principal star of Boötes the Herdsman. This asterism extends almost to the zenith and contains quite a number of bright doubles. About half way from Arcturus to the horizon, west of south, the ruddy planet Mars keeps company with the brilliant Spica in the constellation of Virgo. The star nearest to Mars to the north is θ Virginis, and almost directly west of this star, 15*m* or 4°, the planet Uranus may be found. The next star visible to the eye, toward the west from θ and Mars, is γ Virginis, one of the finest of double stars, a binary with a period of about 180 years. The components are of the 4th magnitude, very nearly equal, 4″ apart, the one silvery white, the other pale yellow. There are many nebulæ in this constellation, but few of them are individually interesting. Southwest from Mars and Spica there is a trapezium of stars, known as Corvus the Raven. To the east of the meridian the first constellation to strike the eye is Scorpio, with the scarlet Antares and irregular configuration of bright stars. It has added to its own charms now the giant planet Jupiter. Antares, besides its fiery red color, has also a close companion of a greenish hue, which is a somewhat difficult object to detect with small telescopes. The bright star, β, nearest to Jupiter is also a double, rather wide, mag-

nitudes 2 and 5.5, colors yellowish white and lilac. The nearest star east of β is also a wide double, magnitudes 4 and 7, and the fainter star of this pair is again double, 2″, magnitudes 7 and 8. Half way between Antares and β is a large nebula like a comet. Directly east of Antares about 2° is a large, rather dim, resolvable cluster of stars followed by a vacant, starless space, one of Herschel's "holes in the sky." The two bright stars of Libra are a little north and west of Scorpio.

North of Scorpio parallel to the Milky Way is the ill-defined constellation of Ophiuchus the Serpent-bearer. To the right of the last one may trace an irregular line of stars, marking the head and neck of the Serpent, North of this we see the Northern Crown ,a circular group of faint stars, and to the left of this Hercules, an asterism difficult to trace because it contains no conspicuous stars and has no definite outline. It is chiefly interesting because it contains that point in the heavens toward which the solar system is supposed to be now moving, and because of the splendid globular cluster which is to be found one-third of the way from the star η to the star ζ of the constellation. These last are the first stars, of the third magnitude, to the east and a little north of the Northern Crown. A line from the zenith to the east horizon will pass near two very bright stars; the uppermost of these is Vega of the Lyre, the lower Altair of the Eagle. One will notice two fainter stars which form an isosceles triangle with Vega. The northernmost of these is ε Lyræ, a double-double, *i. e.*, to the naked eye it appears single, with a low magnifying power double and with a higher power each component is again double. A little way toward the horizon from Vega is another pair of stars of nearly the same brightness and nearly the same distance apart as those nearest Vega. Between these, about half way and almost directly in line, the famous Ring Nebula may be found. Looking towards the north one will see Ursa Major to the west, Ursa Minor and Draco above, Cepheus and Cygnus to the east and Cassiopeia below the pole.

Phases of the Moon.	Central Time. d h m
Last Quarter.....	June 1, 6 53.3 A. M.
New Moon.....	9, 10 34.0 "
First Quarter.....	17, 12 49.7 "
Full Moon.....	23, 3 7.5 P. M.
Last Quarter.....	30, 9 52.6 "

NEPTUNE.

		R. A. h m	Decl.	Rises. h m		Transits. h m		Sets. h m	
June	5.....	3 54.2	+18°39′	3 31	A. M.	10 52.2	A. M.	6 13	P. M.
	15.....	3 55.7	+18 43	2 53	"	10 14.3	"	5 36	"
	25.....	3 57.1	+18 47	2 14	"	9 36.4	"	4 58	"

SATURN.

June	5.....	8 22.8	+20 02	7 56	A. M.	3 24.0	P. M.	10 52	P. M.
	15.....	8 27.2	+19 48	7 22	"	2 49.0	"	10 16	"
	25.....	8 31.8	+19 32	6 49	"	2 14.3	"	9 40	"

URANUS.

June	5.....	12 49.7	−4 36	2 05	P. M.	7 50.0	P. M.	1 35	A. M.
	15.....	12 49.3	−4 35	1 25	"	7 10.4	"	12 56	"
	25.....	12 49.3	−4 35	12 46	"	6 31.1	"	12 16	"

MARS.

June	5.....	12 48.7	−5 13	2 06	P. M.	7 49.3	P. M.	1 32	A. M.
	15.....	12 56.4	−6 22	1 40	"	7 17.8	"	12 56	"
	25.....	13 7.7	−7 47	1 17	"	6 49.7	"	12 22	"

JUPITER.

June	5.....	15 50.8	−19 10	6 06	P. M.	10 50.5	P. M.	3 34	A. M.
	15.....	15 46.2	−18 57	5 22	"	10 6.6	"	2 52	"
	25.....	15 42.4	−18 47	4 38	"	9 23.5	"	2 09	"

VENUS.

June	5.....	4 15.0	+20 40	3 47	A. M.	11 17.9	A. M.	6 48	P. M.
	15.....	5 7.2	+22 22	3 50	"	11 30.7	"	7 12	"
	25.....	6 0.4	+23 39	3 59	"	11 44.6	"	7 30	"

MERCURY.

June	5.....	6 38.3	+25 03	5 46	A. M.	1 40.0	P. M.	9 33	P. M.
	15.....	7 22.5	+22 32	6 04	"	1 44.7	"	9 24	"
	25.....	7 37.3	+19 33	5 54	"	1 19.9	"	8 45	"

THE SUN.

June	5.....	4 55.7	+22 39	4 21	A. M.	12 01.6	P. M.	7 42	P. M.
	15.....	5 37.1	+23 21	4 15	"	11 59.6	"	7 44	"
	25.....	6 19.7	+23 23	4 13	"	11 57.5	"	7 42	"

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	Angle f'm N. Point. °	EMERSION. Wash. Mean T. h m	Angle f'm N. P't. °	Duration. h m
June 18	80 Virginis	6	9 48	136	10 56	278	1 07
21	$\varkappa$ Ophiuchi	4½	8 31	182	8 56	221	0 25
26	γ Capricorni	3½	12 05	63	13 26	268	1 18
26	δ Capricorni	2½	16 40	71	17 56	241	1 17
27	B. A. C. 7835	6½	11 12	346	Star 6.5′ N. of moon's limb.		

Great Red Spot on Jupiter—Times when its Zero Meridian passes the Centre of Jupiter's Disc.

	Central Time. d h m		Central Time. d h m		Central Time. d h m	
June	2, 1 27.8	A. M.	June 11, 11 42.6	P. M.	June 21, 9 57.9	P. M.
	2, 9 18.9	P. M.	12, 7 33.8	"	22, 5 49.1	"
	4, 3 6.0	A. M.	14, 1 20.8	A. M.	23, 11 36.1	"
	4, 10 47.2	P. M.	14, 9 11.9	P. M.	24, 7 27.4	"
	5, 6 48.2	"	16, 2 58.9	A. M.	26, 1 14.4	A. M.
	7, 12 35.2	A. M.	16, 10 50.2	P. M.	26, 9 5.7	P. M.
	7, 8 26.3	P. M.	17, 6 41.4	"	28, 2 52.7	A. M.
	9, 2 13.2	A. M.	19, 12 28.4	A. M.	28, 10 44.1	P. M.
	9, 9 4.5	P. M.	19, 8 19.6	P. M.	29, 6 35.4	"
	11, 3 51.3	A. M.	21, 2 6.6	A. M.	July 1, 12 22.4	P. M.

Phenomena of Jupiter's Satellites.

	Central Time. d	h	m			Central Time. d	h	m		
June	1,	7	18	P. M.	I Ec. Re.	June 15,	8	21	P. M.	I Oc. Dis.
	3,	3	29	A. M.	II Oc. Dis.	15,	11	06	"	I Ec. Re.
	4,	10	27	P. M.	II Tr. In.	16,	6	05	"	I Sh. In.
	5,	12	07	A. M.	II Sh. In.	16,	7	42	"	I Tr. Eg.
	5,	12	55	"	II Tr. Eg.	16,	8	17	"	I Sh. Eg.
	5,	1	37	"	II Sh. Eg.	18,	7	00	"	III Ec. Re.
	6,	2	51	"	I Tr. In.	20,	9	11	"	II Oc. Dis.
	6,	3	13	"	I Sh. In.	21,	1	01	A. M.	II Ec. Re.
	6,	7	48	P. M.	II Ec. Re.	22,	12	51	"	I Tr. In.
	7,	12	10	A. M.	I Oc. Dis.	22,	1	31	"	I Sh. In.
	7,	2	43	"	I Ec. Re.	22,	6	36	P. M.	II Tr. Eg.
	7,	9	17	P. M.	I Tr. In.	22,	8	03	"	II Sh. Eg.
	7,	9	29	"	III Tr. In.	22,	10	07	"	I Oc. Dis.
	7,	9	42	"	I Sh. In.	23,	1	00	A. M.	I Ec. Re.
	7,	10	58	"	III Sh. In.	23,	7	17	P. M.	I Tr. In.
	7,	11	07	"	III Tr. Eg.	23,	8	00	"	I Sh. In.
	7,	11	29	"	I Tr. Eg.	23,	9	29	"	I Tr. Eg.
	7,	11	53	"	I Sh. Eg.	23,	10	12	"	I Sh. Eg.
	8,	12	53	A. M.	III Sh. Eg.	24,	7	29	"	I Ec. Re.
	8,	6	36	P. M.	I Oc. Dis.	25,	6	04	"	III Oc. Dis.
	8,	9	12	"	I Ec. Re.	25,	7	51	"	III Oc. Re.
	9,	5	56	"	I Tr. Eg.	25,	9	14	"	III Ec. Dis.
	9,	6	23	"	I Sh. Eg.	25,	10	59	"	III Ec. Re.
	12,	12	44	A. M.	II Tr. In.	27,	11	31	"	II Oc. Dis.
	12,	1	42	"	II Sh. In.	29,	6	26	"	II Tr. In.
	12,	3	10	"	II Tr. Eg.	29,	8	08	"	II Sh. In.
	13,	6	53	P. M.	II Oc. Dis.	29,	9	54	"	II Tr. Eg.
	13,	10	25	"	II Ec. Re.	29,	10	37	"	II Sh. Eg.
	14,	1	56	A. M.	I Oc. Dis.	29,	11	54	"	I Oc. Dis.
	14,	11	5	P. M.	I Tr. In.	30,	9	03	"	I Tr. In.
	14,	11	38	"	I Sh. In.	30,	9	55	"	I Sh. In.
	15,	12	49	A. M.	III Tr. In.	30,	11	15	"	I Tr. Eg.
	15,	1	17	"	I Tr. Eg.	July 1,	12	07	A. M.	I Sh. Eg.
	15,	1	50	"	I Sh. Eg.					

Comet *a* 1888 (Sawerthal) was observed at Carleton College Observatory by Dr. H. C. Wilson on the morning of May 19. It was easily visible in the finder of the 8¼-inch Clark equatorial. The tail could be traced for more than a degree and the central bright line is still visible for its entire length. The following ephemeris is from A. N., No. 2838 for the months of June and July:

1888		*a* 1888.0 h	m	s	*δ* 2888.0 °	′	″	Log *r*	Log Δ	*b*
June	1	0	27	11	+ 40	1	6			
	2		28	45	40	20	7			
	3		30	18	40	39	6	0.2052	0.2826	0.067
	4		31	49	40	58	3			
	5		33	18	41	16	7			
	6		34	46	41	34	9			
	7		36	12	41	52	8	0.2205	0.2899	0.060
	8		37	36	42	10	5			

1888	α 1888.0	δ 1888.0	Log r	Log Δ	L.
	h m s	° ″			
June 9	0 38 59	+ 42 28.0			
10	40 20	42 45.2			
11	41 39	43 2.2	0.2352	0.2965	0.055
12	42 56	43 19.0			
13	44 12	43 35.7			
14	45 26	43 52.1			
15	46 38	44 8.3	0.2493	0.3025	0.050
16	47 48	44 24.3			
17	48 57	44 40.2			
18	50 4	44 55.9			
19	51 9	45 11.4	0.2629	0.3080	0.046
20	52 12	45 26.7			
21	53 14	45 41.8			
22	54 14	45 56.7			
23	55 11	46 11.5	0.2760	0.3129	0.042
24	56 7	46 26.1			
25	57 1	46 40.5			
26	57 52	46 54.8			
27	58 42	47 8.9	0.2887	0.3173	0.039
28	0 59 30	47 22.8			
29	1 0 16	47 36.6			
30	1 0	47 50.2			
July 1	1 1 42	48 3.7	0.3009	0.3212	0.036
2	2 22	48 17.0			
3	3 0	48 30.2			
4	3 36	48 43.2			
5	4 9	48 56.0	0.3127	0.3247	0.033
6	4 40	49 8.7			
7	5 9	49 21.2			
8	5 36	49 33.5			
9	6 1	49 45.7	0.3241	0.3278	0.031
10	6 24	49 57.7			
11	6 44	50 9.6			
12	7 2	50 21.3			
13	7 18	50 32.8	0.3352	0.3306	0.029
14	7 31	50 44.2			
15	7 42	50 55.4			
16	7 50	51 6.4			
17	7 56	51 17.2	0.3459	0.3331	0.028
18	8 0	51 27.9			
19	8 2	51 38.4			
20	8 1	51 48.7			
21	7 57	51 58.8	0.3563	0.3353	0.026
22	7 51	52 8.7			
23	7 43	52 18.5			
24	7 32	52 28.0			
25	7 19	52 37.4	0.3664	0.3372	0.025
26	7 3	52 46.5			
27	6 45	52 55.4			
28	6 24	53 4.2			
29	6 0	53 12.6	0.3762	0.3380	0.023
30	5 34	53 20.9			
31	1 5 6	53 28.9			

CLOCK-WORK OF THE TELESCOPE.*

A great variety of these are used by different makers, all more or less effective. Except for extraordinary purposes, the ordinary frictional governor is probably the best, as it is certainly the most common, form.

The principal points to be looked to in the clock are:

1st. Sufficiency of power—*i. e.* not only sufficiency of power to drive instruments under ordinary circumstances, but sufficient also to leave a large margin for possible and probable hitches or differences in force required owing to want of balance or any of those numerous causes which tend to vary the friction of any instrument.

To give an idea of what may be called sufficient, measure the height the clock-weight falls in an hour, and multiply this in feet by the number of pounds weight; the product will be the number of foot-pounds of energy available in each hour.

A 4″ telescope should not have less than 75, and a 6″ less than 200, foot-pounds of energy per hour.

These rough figures will give an idea of what is required, but of course much depends on the character of instrument, and its weight, and the fineness of finish of bearings, etc.

2nd. The train between clock-governor and clock-screw should be as simple as possible, with as few wheels as possible, as short shafts as possible; and, lastly, the gearing up between clock and screw should be as far as possible made with spur instead of bevel gearings. It is not the slightest consequence how complicated the train be anywhere else except between governor and screw but every avoidable wheel introduced there increases the chance of error.

3rd. The governor or regulator should be heavy, and have as much momentum as possible, to enable clock to get over small obstacles without preceptible jerk.

Various forms of improved governors have been introduced from time to time, but none are better than the simple frictional governor for short periods, and this is what is generally required.

If the telescope be required for photographic use, in which

* From "Astronomy for Amateurs," the article entitled "The Telescope" by Sir Howard Grubb, and continued from page 112 of the MESSENGER.

case the star must be kept constant in position for two hours without $\frac{1}{10}$ of a second displacement, the only resource is that of a uniform clock controlled electrically from a pendulum clock; but this arrangement is too complicated to attempt to describe without diagrams. It should be remembered that all these points are more or less important according to the delicacy of the work proposed to be undertaken. If the instrument be intended only for gazing at planets, stars, and comets, these points are of comparatively little consequence; but an instrument quite equal to this work would be useless if it were required to use very high powers for dividing difficult double stars, etc.; and again, an instrument might be sufficiently stable and rigid for this last purpose and not be sufficiently so if delicate micrometrical work were to be attempted.*

A new Minor Planet, No. (277), was discovered by Charlois, of Nice, May 3.5170, R. A. 13*h* 42*m* 17.4*s*; Decl.—11° 13′ 43″. Daily motion—44*s* and +.4′. Magnitude 13.

A new Minor Planet, No. (278 ?), was discovered by Borrelly, May 12.4336, R. A. 16*h* 31*m* 46*s*. Decl.—21° 47′ 06″. Motion in R. A.—56*s*; in Decl. +.03′. Magnitude, 11. This is perhaps Xantippe, No. (156).

A new Minor Planet, No. (279?), was discovered by Palisa, of Veinna, May 16.5483; R. A. 16*h* 21*m* 8*s*. Decl.—21° 35′ 12″. Daily motion in R. A.—56*s*; in Decl. +.01′; Magnitude 12.

Minor Planet No. (269) has received the name *Justitia*; No. (273), *Atropos*, and No. (274), *Philagoria*.

* Much stress has been laid on the driving clock as an indispensable adjunct to the equatorial, though, from the amateur's point of view, it is still an expensive luxury; and, if the telescope is not to be especially devoted to micrometrical or photographic work, the ordinary tangent-screw, worked by hand, will suffice for most purposes. A sidereal timekeeper is almost a *sine qua non* in the effective use of the equatorial mounting; but an old-fashioned eight-day clock, beating seconds, with a slight alteration in its wheel-work and dial, makes a capital substitute at a merely nominal cost.—W. S. P.

ANAHITA.

Discovered by Dr. Peters, and presented to Anita Rosalie, daughter of Professor Simon Newcomb.

FOR THE MESSENGER.

Deep hidden in the depths of space,
Fain would I see her charming face,
As she moves on with subtle grace—
Anahita!

O brave Columbus of the skies,
Her beauty met thy searching eyes,
And filled our hearts with glad surprise—
Anahita!

She heedeth not the moon, I ween,
The little spot where she is queen
She rules with such an air serene—
Anahita!

O wondrous star of silver light,
Fit for the crown of angel bright,
Could I but hail thee in the night,—
Anahita!

Earth, thou hast many scenes sublime,
Yet I would leave this changeful clime;
To say farewell, I bide my time,—
Anahita!

Say not the new world is too small;
The green trees there may grow as tall,
Their verdant leaves may never fall—
Anahita!

The oceans here are are all too large,
But there I'll float a fairy barge
Upon the blue sea's sunny marge—
Anahita!

A sweeter music than we know,
From many a singing brook may flow;
While poet's hearts with fervor glow—
Anahita!

And what sequestered vales are there!
To break the silence of whose air,
Only the birds and lovers dare—
Anahita!

How beautiful the azure dome
Seen from those fields! O, let us roam
Where every flower finds its home—
Anahita!

There we shall see the roses blown
To perfect fullness; sweeter grown
The pansy faces we have known—
Anahita!

O happy little world above,
As free from guile as is the dove,
But full of faith and hope and love—
Anahita!

Too small is she for any wrong
But large enough for mirth and song,
And all that doth to joy belong—
Anahita!

Clinton, N. Y. —LUCY STANTIAL BORST

EDITORIAL NOTES.

Vacation months follow this. There will be no issue of the MESSENGER for July, but a number will be published for August. Consecutive numbers will always be found at the top of the first cover page.

The Orbits of Aerolites by Professor Newton. The following two propositions were set forth by Professor Newton in his paper read April 19 to the National Academy of Sciences:

1. The meteorites which we have in our collections, and which have been seen to fall, were originally (as a class, and with a very small number of exceptions) moving about the

sun in orbits that had inclinations to the ecliptic less than 90°; that is, their motions in the solar system were direct and not retrograde.

2. The reason why we have only this class of stones in our collections is not a reason wholly, or even mainly, dependent on the habits of men; nor on the time when men are out of doors; nor on the places where men live; nor on any other principle of selection acting at or after the arrival of the stones at the ground. Either the stones which are moving across the earth's orbit in the solar system move in general in direct orbits, or else, for some reason, the stones which have retrograde orbits do not in general come through the air to the ground in solid form.

Denver University Observatory. A recent letter from Professor H. A. Howe, of Denver University, Colorado, discloses the interesting fact that the observatory at that place is to have a new equatorial refracting telescope the aperture of whose object glass will be twenty inches. This is good news for the University and for Professor Howe who well deserves the recognition it implies. For so young a man it is a noteworthy stride in his favorite science, to have a telescope that ranks fifth in size and power in the United States; for those at Lick Observatory, Washington, University of Virginia, and Princeton, only now are larger. Another significant fact in this new enterprise is the altitude of the site, which has been chosen on the new "Campus" of the University about seven miles from the city of Denver, and is 5,000 feet above sea level. If memory serves us rightly this site is higher than that of any other large telescope in the United States, the Lick site being next, at an altitude of 4,200 feet. The name of the generous donor of this large instrument is Mr. H. B. Chamberlin of Denver, Colorado, whom the MESSENGER is pleased to introduce to all its readers as a patron of science they should know and gratefully remember.

Double Nucleus and Comet a 1888. I desire to supplement my former letter about the double nucleus of Comet Sawerthal with additional particulars. Duplicity was confirmed by observation on the same morning (April 5 '88) by E. E.

Barnard with twelve-inch equatorial while visiting at Lick Observatory. Mr. Barnard's sketch made subsequently from memory corresponds with mine already sent you (p. 221, April MESSENGER) I have since examined the comet previous to micrometrical measures each clear morning. I suspected two nuclei April 11 A., M. and saw them distinctly April 13. On last mentioned date, the central shaft of light (in tail) read 4°.7, and line joining nuclei 14°.6, to *north* of zero on position circle. CHAS. B. HILL.

Smith Observatory. Astronomers will be interested to notice, if not already known, that William R. Brooks, so well known everywhere for remarkable comet discoveries, has removed from Phelps, N. Y., to Geneva ,eight miles distant His change of place is due to the interest of another patron of Astronomy by the name of William Smith a resident of Geneva, who has provided Mr. Brooks with a fine residence and an Observatory delightfully situated and fully equipped for astronomical work. Address him hereafter at "Smith Observatory," Geneva, instead of "Red House Observatory," Phelps, N. Y., as heretofore. His observatory and instruments will be more fully described in a later issue.

Photographing the Sky. The first fasciculus of the "Bulletin of the Permanent International Committee for the Photographic Execution of a Chart of the Sky" has just come to hand. It contains much interesting matter. The principal papers are: Regulations of the Bureau of the Permament Committee; Method of mounting the sensitive plates and determining their orientation, by Mr. D. Gill; Note on the application of photography to micometric measures of stars, by Mr. T. N. Thiele. On the influence of the duration of exposure on the exactitude of stellar photography, by Mr. J. Scheiner. Then follows correspondence concerning the preparatory researches, by Messrs. Abney, Eder, Bakhuysen, Christie, Dunér, Gill, Jannsen, Pickering, Struve, Trépied, Vogel and others.

The president of the bureau, Admiral Mouchez, announces that the Bulletin will appear whenever the bureau has any memoir to publish, or any important report to bring to the

knowledge of the savants and observatories who are carrying out the decisions of the astrophotographic congress of last April.

The following list of the observatories which had up to March 1, 1888, ordered the instruments necessary to take part in the work, is appended:

Germany—Potsdam.
England—Oxford.
Australia—Melbourne, Sydney.
Brazil—Rio de Janeiro.
Chili—Santiago.
Spain—San Fernando.
France—Paris, Bordeaux, Toulouse, Alger.
Mexico—Tacubaya.
Argentine Republic—La Plata. H. C. W.

The Editor of Knowledge in the April number pays his respects to us, under Gossip, to the extent of considerable space. We notice only one sentence, in which he says: "The editor of THE SIDEREAL MESSENGER actually asks me—an Englishman—how I could feel certain that the Council of the (Royal) Astronomical Society would reject a man (meaning Professor Holden) with contempt who has been convicted of unworthy conduct." That was not the question asked, as the editor of *Knowledge* ought to know, and should have stated fairly. The question to him was, how he could certainly know, before the election of the Council took place, that Professor Holden would be rejected with contempt. The editor of the MESSENGER has never said nor claimed to know, that Professor Holden was "guilty of falsehood, chicanery and malice," as *Knowledge* distinctly charges.

The foreknowledge of the editor of *Knowledge* is a little too previous, and also rather bold for even an American to receive, who does not believe that that English gentleman carries the Council of the Royal Astronomical Society in his vest pocket. In its May issue the *Observatory* (English) has again spoken well in this matter.

Mr. Ambrose Swasey, of the firm of Warner and Swasey, Cleveland, Ohio, spent a day at Carleton College Observa-

tory recently, on his return trip from California. He has employed a considerable portion of the winter months at Mt. Hamilton in setting up and trying the great Lick telescope, the mounting for which was constructed by the above named firm. Mr. Swasey gave us valuable suggestions in regard to the practical manipulation of photographic apparatus in connection with the telescope. His experience with the great thirty-six-inch photographic lens, though limited in time, was certainly instructive.

Messrs. Fauth & Co., makers of astronomical instruments, Washington, D. C., have kindly sent us blue-print drawings of a mounting for an equatorial telescope with several interesting improvements invented by Mr. Saegmüller who is connected with this well known firm.

Astronomy in Rochester, N. Y., is a popular study. From a late issue of the *Union and Advertiser* these interesting items were taken: William M. Rebasz is the possessor of an excellent six-inch refracting telescope by the Clarks. William Streeter has a small equatorial telescope mounted in an observatory of novel design. Rev. N. M. Maain has an equatorial telescope and an observatory, and has written much for the MESSENGER. H. C. Mann owns three telescopes, one refractor and two reflectors, the largest of the mirrors being twelve inches in diameter. Isaac Goldenschuhe has a six-inch reflector of excellent defining power. Professor Otis H. Robinson of the University of Rochester has a small Clark refractor of superior quality. The larger Clark refractor of the Warner Observatory is, however, the chief attraction. Its cost was $11,000; its aperture sixteen inches and its focal length twenty-two feet. Dr. Lewis Swift, more than any other, is undoubtedly the cause of this rapid advancement in the study of astronomy. Dr. Swift made Rochester his home in 1872.

Shattuck School of Faribault, Minn., has recently secured an 8½-inch, equatorially mounted reflecting telescope, made by J. A. Brashear, Allegheny City, Pa. Similar instruments have also been ordered from the same maker for a station in British Columbia, and by Dr. J. G. W. Steedman of St. Louis, Mo. The driving clocks for these instruments are said to work excellently and almost noiselessly.

Mars' Satellites. It may be interesting to some of our readers to know how the tiny satellites of Mars look in the great Lick equatorial, as they have been observed night after night by Assistant Keeler, during the month of May. In conversation with a friend he recently said these minute bodies looked in the great refractor as bright as the companion to Polaris does in a three-inch telescope. Mr. Barnard's estimate of their brightness in April was that they were equal to Jupiter's satellites when viewed with a glass of 1½-inches aperture. They are evidently easy objects to observe in the world's greatest refracting telescope.

Correction. On page 222 of the May MESSENGER, for the name of James G. Davidson, Professor Swift should have written James S. Lawson.

Intersecting Rainbows. The following interesting letter from John G. Hagen, S. J., College of the Sacred Heart, Prairie du Chien, Wis., under date of May 23, contains important observations for Hansteen's theory of intersecting rainbows:

The interesting note of Professor C. W. Prichett in your No. 65 on intersecting rainbows calls to my mind two observations of the same phenomenon, which, in compliance with the desire expressed in the article above mentioned, I gladly communicate to the MESSENGER, as follows:

In the year 1876, about spring time, two intersecting rainbows were observed at sunset by several of my friends, one of whom was professor of physics. The station of observation was Ditton Hall, near Widness, in Lancashire. Although I had not seen the phenomenon myself, there was no doubt as to the correctness of the statement.

The second observation I quote from my observing book: "Prairie du Chien, Wisconsin, May 13, 1886. Two rainbows intersecting above the southern horizon at $6^h\ 25^m$ P. M., the one being almost vertical, the other apparently corresponding to the altitude of the sun. The vertical branch disappeared a few minutes later."

In relating these facts in the class room, I used to mention that in the first case the Mersey between the observer and the rainbow, and in the second case the Mississippi between

the sun and the observer, both rivers lying only some thousand feet from the place of observation, probably produced the secondary rainbows, by reflection of the sun's rays, although Hansteen's explanation published in 1823 was unknown to me until I saw Herr Geelmuyden's letter in your last number.

The Tangent Index. Professor John Haywood, Otterbein University, Ohio, has been for some time at work on an instrument called the Tangent Index, which is designed to explain the chief motions of the earth, and to furnish some help to those who are studying the elements of astronomy and wish to be occupied only with the most important of those relations. We have before stated the principles of the instrument, and now take pleasure in calling attention to a very neat little pamphlet the subject of which is the earth and its chief motions and the Tangent Index.

Wolsingham Observatory. Under date May 16, T. E. Espin announces, in Circular, No. 20, the observation of an 8.1 magnitude star on the nights of May 8 and 9, R. A. $20^h\ 41^m\ 7^s$; Decl. $+44°24'$ (1855). The color of the new star is red; its spectrum is not continuous and it is not found in DM.

Map of Solar Spectrum. At the April meeting of the National Academy of Sciences, Professor Rowland of Johns Hopkins University presented two brief papers giving further studies on certain spectra. With new and improved instruments made at the university it is claimed that he has succeeded in making a much more perfect map of the solar spectrum than his former one. Definition of the lines is better, and some single lines have been divided. He also claims the discovery that carbon is much more widely distributed in the sun than has previously been known.

The Polemic Problem. If any person is interested in the bibliography of the Polemic problem, send to S. C. Gould, Editor of *Notes and Queries*, Manchester, N. H., and get his pamphlet of 32 pages wholly devoted to this theme. It gives a pretty correct idea, probably, of the immense labor expended in finding the value of π by the aid of Cyclometry, Quadrature and Rectification.

Ciel et Terre of Brussels (French), has in its May number, a full account of the Lick Observatory, with two page cuts, copies of those which appeared in the *Scientific American*. The subject matter of the article is credited to the SIDEREAL MESSENGER.

The Literary Magazine, April 14, has a very glowing account of the work of Dr. T. Sterry Hunt and that of Richard A. Proctor, at their respective places of residence near each other, on the banks of Orange Lake, at Oaklawn, Florida, It calls the former the "Darwin of Geology" and the latter the "Darwin of Astronomy."

Progress of Astronomy during 1887. At the April meeting of the Astronomical Society of France, M. C. Flammarion, president of the society, gave the address on the progress of astronomy for 1887. The survey of the present field of astronomical work was general with special reference to new features and new instruments.

Observations of Comet a 1888, by H. C. Wilson at Carleton College Observatory:

	Local mean time.	$\Delta\alpha$	$\Delta\delta$	No. of Comp.	Star.
	h m s	m s	′ ″		
May 18	14 38 00	+6 10.27	−0 06.5	4, 4	1

	α app.	l. f. p. α	δ app.	l. f. p. δ
	h m s		° ′ ″	
	0 03 11.67	9.710n	+35 11 12.5	0.667

ASSUMED PLACE OF COMPARISON STAR.

α 1888.0	Red. to app.	δ 1888.0	Red. to app.	Authority.
h m s	s	° ′ ″	″	
23 57 01.70	−0.30	+35 11 29.7	−10.7	Second Armagh Catalogue 3288.

A comparison of this observation with the ephemeris by Professor Boss in *Astronomical Journal*, No. 171, gives $(c-o)$ $\Delta\alpha = +3.1$s, $\Delta\delta = +25''$.

Pacific Earthquakes. Professor Holden of Lick Observatory, has recently prepared a list of recorded earthquakes in California, Lower California, and Washington Territory, as computed from published works and from private information. Especially the sources of information have been:

1. Printed lists of earthquake shocks in the scientific journals, such as the lists of Mallet, Perrey, Rockwood, Fuchs, Trask, and others.

2. Accounts of earthquakes in printed books, magazines, and newspapers.

3. Lists of shocks put at Professor Holden's disposition by various gentlemen; specially a list by Thomas Tennant of San Francisco, a list by Professor H. G. Hanks, and a very extensive collection furnished by H. H. Bancroft from manuscript records.

This valuable pamphlet of 78 pages of closely printed matter is the beginning of scientific work in this direction at the Lick observatory and the University of California. Instruments for accurate registration of earthquake shocks and tremors are now in use at other points, and systematic study of the regions west of the Sierras will follow.

Dearborn Observatory. In a recent letter from Professor Hough, we learn that all the astronomical instruments belonging to Dearborn Observatory have been removed to Evanston, the new site of the observatory. Plans for the new building have been adopted, and its erection was to begin about the first of May, but the 18½-inch equatorial will not be mounted before January, 1889. The meridian circle has been placed in a temporary building located 250 feet from the shore of Lake Michigan. Professor Hough says the lake seems to have no effect on nadir observations, at least, a moderate storm does not disturb the images perceptibly. In case of a gale, he thinks it is possible that tremors would be felt. The site of the new observatory is to be 250 feet from the lake shore.

Professor Hough is now arranging for the time service for Chicago from his new location.

The Large Dome for Carleton College Observatory. The 30-foot dome, built by Messrs. Warner & Swasey, of Cleveland, Ohio, is now being put in place at the new observatory of Carleton College, under the direction of Messrs. Lucas and Carr, employes of the above named firm. The troublesome problem of protecting the observatory building while the dome is being set in place has been mastered in a novel manner by Mr. D. H. Lord, builder of the observatory. The temporary flat roof which has been in the place of the dome for the last year, has been mounted on vertical supports, underneath which are placed a set of jack-screws by which the roof is raised and lowered morning and evening easily in a few minutes of time. So the work is progressing rapidly and safely, and probably will be completed before the middle of the present month. A cut and discription of this new building will probably be ready for the next number of the MESSENGER.

BOOK NOTICES.

The New Astronomy, Illustrated. SAMUEL PIERPONT LANGLEY. Ph. D., LL.D. Ticknor and Company, 211 Tremont Street, Boston. Royal Octavo, 260 pp. $5.00.

This beautiful popular work on Astronomy merits the highest praise for the artistic work of the publishers, and the value of its subject matter in the text and illustrations. The chapters are the Spots on the Sun, the Sun's Surroundings, the Sun's Energy, the Planets and the Moon, Meteors, Comets, and the Stars, together with an Index. The engravings are elegant in finish and are many of them derived from drawings made at Allegheny City.

It is one more argument to show that the masters of astronomy, in their own departments, are not only willing but most capable of instructing and delighting the public in these subjects, thereby rendering the work of compilers superfluous to the world as well as to the profession. There will be no risk in asserting that all students of the sun, moon and stars will find help in this volume in clarifying their ideas by means of these illustrations; for in fact the imagination is best instructed by seeing. We mention in particular the drawings of sun-spots. It should be also said that all students of Astronomy regret, as deeply as Professor Langley, the fact that we possess in the United States no great and well-equipped physico-astronomical observatory. That the Directors at Cambridge, Princeton and Allegheny have already secured results which make us proud as Americans, by dint of their personal ability, is no reason why this state of things should continue. We hope that the appeal contained in Professor Langley's volume will culminate in the foundation of such an Observatory worthy of our rank in Astronomical Science.

F. H. B.

Elements of the Differential and Integral Calculus, by SIMON NEWCOMB, Professor Mathematics in the Johns Hopkins University. New York: Messrs. Henry Holt & Co., publishers. 1887, pp. 307.

The author has written this book for the use of the undergraduate student in a course of arts or science, and he has chosen about the usual matter found in most good text books in this delightful branch of study now found in many

American colleges and special schools of science. He brings early to notice the troublesome question how the first principles of this science should be presented to the mind of the beginner. He claims that this should be done by laying down the logical basis on which the whole superstructure rests; that it is now well understood that the method of limits is the only rigorous basis for the infinitesimal calculus, and that infinitesimals can be used logically only when based on this method because they flow from it, if the theory has any true significance at all.

This statement of the case is a pretty strong one. It is fully as positive as any given by the friends of the theory of limits that we remember to have seen. If all that is claimed is true, and that only true, then the statement is not too strong; but if not wholly true with regard to the origin, theory, and use of the infinitesimal quantity, then the claim is more than unfortunate for the calculus. It seems to us that the theory of limits offers some difficulties in explaining the infinitesimal. In defining *limit* the author uses this language nearly:

"The limit of variable x is l, which we conceive x to *approach* in such a way that the difference, $l-x$, becomes less than any quantity we can name, but which we do not conceive x to *reach*. An *infinitesimal* quantity is one considered in the act of becoming less than any quantity which we can name, that is, in the act of approaching zero as a limit."

Now, by the definition of limit, x cannot equal l, for x can only *approach* l as a *limit*. Also the *infinitesimal* cannot equal o, but can only *approach* it, because o is the *limit*. In explaining the elemental operations, the increment of x (Δx) is used, as an intermediate step, and then to obtain the infinitesimal, the statement is constantly made, "pass *to* the the limit" and then Δx becomes dx. This passing *to* the limit is impossible if the language of the definition be good. But the real question is, does Δx, in becoming dx, actually become o? If it does, then dx is not an infinitesimal, if o is the limit, and if o does not have more meanings than one. Whether o has more meanings than one or not, this is certainly true, that dx is o in relation to Δx, which is thought of as a small finite quantity. There are other inconveniences in the method of limits to say the least, in explaining the

calculus which we constantly meet in the class room whenever we attempt a philosophical account of the origin of the infinitesimal quantity.

We like this book in many things. On every difficult point on which the student or teacher is likely to want knowledge he will find fresh help under the appropriate head. The applications of the differential calculus are full, varied, and well chosen.

The second part of the book is devoted to the integral calculus. Chapter first gives the elementery forms; the following chapter, those integrals immediately reducible to the elementary forms, and then integration by rational transformation; integration of irrational algebraic differentials; integration of transcendent functions, of definite integrals, and successive integration. The applications are rectification of quadrature and the cubature of volumes. The book is nicely printed, and there is as much calculus within the limits of 307 pages as the student will find anywhere probably.

Some Higher Plane Curves, by JOHN BORDEN, Chicago.

Under the above title, the author proposes to consider some of the higher equations by means of their deviations and the curves they generate, when the ordinate is taken to be the first power and the coefficients are real. By root he means the value of x when the second member of the equation is 0. It is thus seen to be a value of x in a special case.

The equation, $x^3+Ax^2+Bx+C=y$, if constructed for the successive real values of x would show each of two quite different figures. Now by use of a straight line it is evident that but one intersection with either locus can be made, if drawn according to certain suppositions imposed; by others three intersections are possible showing three real roots. Then by use of the diffierential coefficients between x and y which bring out the turning points and the law of the locus interesting results are made easily apparent.

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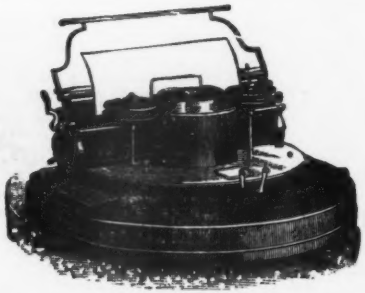

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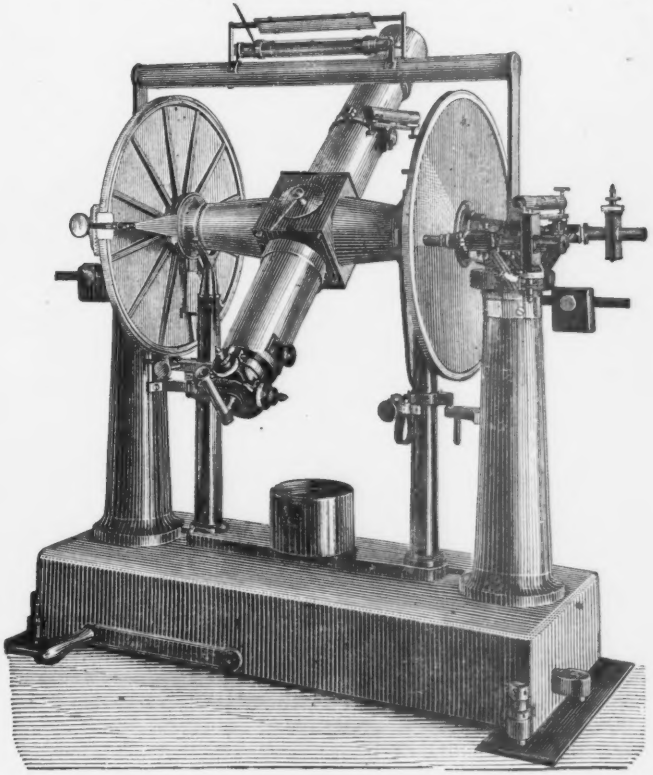

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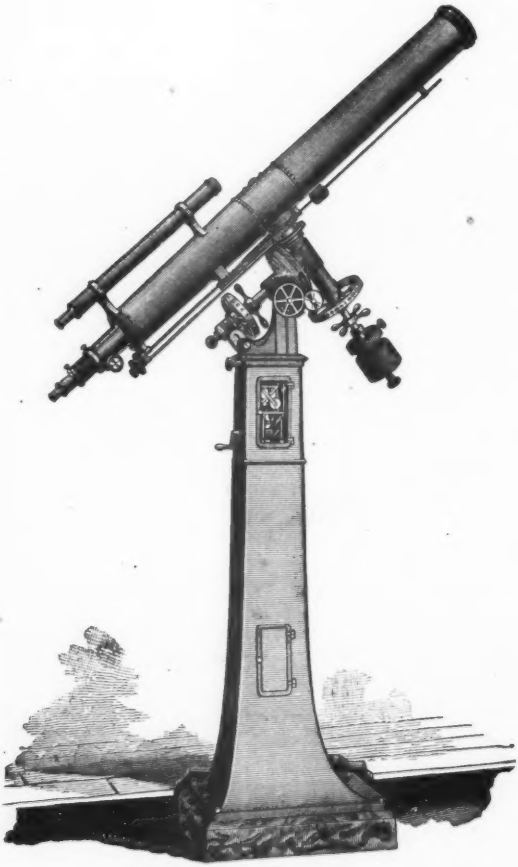

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